The development of mobile is critically dependent on standards

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The development of mobile standards has been a key factor in the widespread success and take-up of second generation (2G) cellular systems. Well thought through standards, including roaming aspects, have enabled operators, using equipment from different manufacturers, to create global mobile networks, which allow users to roam seamlessly and obtain largely the same services wherever they happen to be. Third generation (3G) standards have built on the success of 2G and have increased the global awareness and applicability. In this light, this paper discusses the background for mobile standards and the factors that are influencing their ongoing development for third generation and beyond.

1. Mobile standards background

The importance of standardisation to the mobile industry is probably best illustrated by the impact of the work on the second generation mobile systems, in particular the GSM (Global System for Mobile Communications) standard. The work was started in the mid-1980s, at about the same time as the launch of commercial first generation cellular networks. A variety of different first generation systems were deployed across Europe and the rest of the world. Network infrastructure and mobile terminals were relatively expensive and market adoption was mainly limited to business users. The objective of GSM standardisation was to create a new pan-European system, where users could continue to get service when roaming across country borders. Economies of scale of larger production volumes were expected to reduce prices.

The impact of the GSM standards work is now clear to see. GSM is effectively a *de facto* world standard, claiming around 60% of the total mobile telephone population, and with coverage in all the continents. GSM terminals and network costs have reduced to such low levels that consumer pre-pay packages can be retailed at £50 or less, and the consumer market has developed such that the penetration of mobile telephones exceeds 50% of the population in many countries.

The mobile communications industry has grown to the point where GSM manufacturers, such as Ericsson, Nokia and Motorola, and global operators, such as Vodafone, are now among the top companies in financial market capitalisation.

The speed and extent of this development is undoubtedly due in large part to the creation of international standards. Had we continued by further developing the differing national first generation standards, the mobile industry could not have come so far, so quickly.

The challenge for third generation standards is to take this further — to create a truly single, world-wide standard. However, the standardisation environment has changed since the early work on GSM and it has been necessary to modify the approach. In particular, there are several key differences which have influenced the way in which 3G standards are being created:

- GSM had been created by ETSI (European Telecommunications Standards Institute) as a European regional standard, and to create a world standard needs the involvement of other standards bodies, for example from the Far East and North America,
- the need to work on a world scale has introduced a wider variety of political and cultural influences on the standards work, where conflicting agendas can put the goal of a single standard at risk,
- substantial investments have now been made in second generation systems and infrastructure — whereas in the transition from first to second generation it had been possible to start with a clean sheet of paper, for third generation there is a strong commercial drive to reuse existing infrastructure and create an evolutionary approach, in order to capitalise on past investments,
- the extent of roaming capabilities with GSM is significant across the globe, and different networks will proceed at different rates towards third generation, but users of 3G will not accept a reduction in roaming capability and this requires intelligent handling of roaming between 3G and 2G — this situation will also lead to more complex combined 2G and 3G handsets,

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- the technology scope of 3G has broadened considerably to embrace data and Internet aspects — while GSM is a largely self-contained standard, for 3G it is necessary to draw on component standards from other bodies, such as the Internet Engineering Task Force (IETF) IP protocols, and this requires co-ordination and collaboration across different standards forums, where quite different standardisation processes are used.

These and other aspects led, in December 1998, to the creation of a new partnership project known as 3GPP (3rd Generation Partnership Project), involving several regional standards bodies working together.

2. Why standards are important

The development of standards benefits users and all sectors of the mobile industry — suppliers, operators and regulators. Examples of these are given in Table 1.

On the counter side, it is important that standards do not stifle innovation, and that product and service differentiation can still be achieved.

In practice, such is the importance of standardisation to the mobile industry, that the creation of standards is a key part of the development process. New terminals and network systems simply cannot be launched without standards in place. One measure of the importance could be the scale of effort on 3G standardisation, where tens of thousands of engineers are already engaged in the standards process. At any time of any day, you could be reasonably certain that there is a mobile standards committee in session somewhere in the world.

3. The 3G standard

The 3G standard is being created against the general background of user expectations and industry imperatives. In theory, a single standard could perhaps be created with a single standards body, including all interested parties. In practice, there are different interests and starting points, in particular the desire to evolve from various second generation start points. Figure 1 shows the estimated market share (customer numbers, world-wide) by technology type. While the GSM technology dominates this chart, there are some important other starting points for evolution to 3G, including the TDMA (DAMPS) system, used widely in North America, PDC used in Japan and the CDMAone standard used in North America and the Far East. To take account of these interests, within the ITU the concept of a family of standards, known as IMT2000, was developed.

In fact a total of five different air interface standards are included in this IMT2000 family, these being:

Table 1 Benefits of standardisation.

Economies of scale	Operators benefit from lower cost infrastructure. User benefit from low cost terminals. Suppliers benefit from large and stable market.
Competitive procurement	Open standards enable interworking of network elements from different suppliers, avoiding long-term lock-in to a single supplier.
Service portability	Users can change to different terminal equipment or move between service provider and network operators while retaining a similar service.
Roaming	Services can be made available outside the user's home network with the goal of having exactly the same look and feel.
Regulatory	Regulators can specify standards for spectrum use, giving a controlled, yet open and competitive basis for licensing. Operators and suppliers can access new markets without being disadvantaged by local standards requirements.
Simplicity of service	Services and terminals operate in a similar fashion, making it easier for users (e.g. use of + symbol for international calls).
Service interworking	Standards can be used to ensure that services work well across different networks.
Applications and services environment	Network and terminal standards enable the development of 3rd party applications, and allow the development of 3rd party value added services.
Spectrum efficiency	Standards enable radio technologies to work together, or in close proximity within the radio spectrum, without undue interference.
Radio technology harmonisation	Standards are needed to ensure that different technologies can work in harmony in the same or similar coverage area without undue interference.

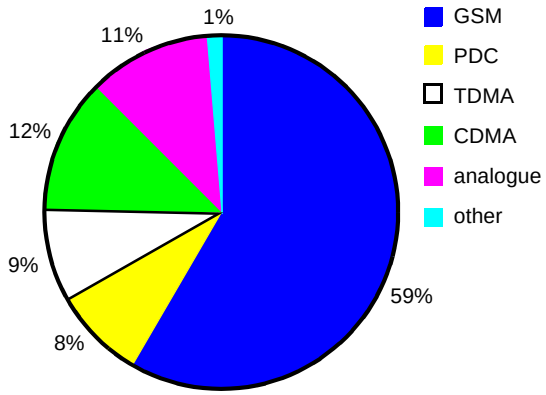

Fig 1 Estimate of market share by technology type.

- CDMA-DS (direct sequence) — specified by 3GPP, also known as UTRA, FDD mode,

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- CDMA-MC (multi-carrier) — specified by 3GPP2, also known as cdma2000,
- CDMA-TDD (time division duplex) — specified by 3GPP, being a combination of the UTRA TDD mode together with the Chinese TD-SCDMA,
- TDMA single carrier — specified by 3GPP, also known as EDGE,
- FDMA/TDMA — specified by ETSI and based on the existing DECT standard.

In addition, there are two different core network standards, one based on evolution from GSM and the other based on evolution from the North American IS41 standard.

While this may seem like a perplexing range of options, there has been some effort to harmonise the different specifications, such that there is some alignment of the key technical parameters within the three CDMA modes, and there are developments to enable each air interface to be used with either of the core network standards. With this set of specifications, each major interest group can find an appropriate evolution path (see Table 2).

Table 2 Evolution options for different interest groups.

2G investment	Example operator*	Evolution options
GSM	BT Wireless	UTRA FDD and/or UTRA TDD with evolved GSM core. EDGE with GSM core.
DAMPS	ATT Wireless	EDGE with evolved GSM or IS41 core.
CDMAone	Sprint PCS	cdma2000, with IS41 core.
PDC	NTT DoCoMo	UTRA FDD with GSM evolved core.

*Note — the 'example operator' column shows examples of operators with the respective 2G investment and does not imply any declared intent to follow any particular evolution path.

From an operator perspective, while this approach gives a reasonable upgrade path to 3G, the variety of standards does present some problems. For global roaming, it may be necessary to support several standards, in order to allow access to service in those parts of the world where the home standard has not been implemented. This will require the use of multi-standard terminals, which currently represent a technology challenge, and are likely to have a cost premium. In addition, it will be necessary to develop cross-standard network interfaces and commercial arrangements. Despite this, the 3G standards landscape is a considerable improvement on the existing 2G multi-standard environment.

From a supplier perspective, the stabilisation of a standards family provides some good opportunities to enter into markets which have been difficult to access. For example, European suppliers have not been able to penetrate into the Japanese market due to the unique standard in use in Japan, while Japanese suppliers have not capitalised on the opportunity to supply to the world GSM market, due to focus on their home market. However, the range of standards and standards bodies does present a significant resourcing challenge, for even the biggest suppliers. This is exacerbated by the fact that all standards options are developing in parallel.

For regulators and governments, the openness of a 3G standards set helps in removing artificial trade barriers, and gives an opportunity to attract competitive overseas bidders to enter into the 3G licensing processes.

4. 3G standards developments — who is doing what?

4.1 3GPP

The GSM community, including ETSI and ANSI-T1 in the USA, along with several Far Eastern standards bodies (ARIB and TTC from Japan, TTA from Korea and CWTS from China), has been brought together by 3GPP [1]. The broad objective of 3GPP is the development of a 3rd generation standard based on a direct sequence wide-band CDMA or time division duplex radio interface, coupled into an evolved core network based on GSM Release 98. This makes a significant advance on GSM by providing much higher data rates, but retains the GSM core network, allowing 2G/3G seamless roaming. Several initiatives which were already in place for GSM are also extended significantly, for example the SIM application tool-kit and the mobile execution environment (MExE), both of which allow a highly customisable terminal environment.

4.2 3GPP2

3GPP2 [2] is another global initiative with support from TR.45 in the USA, ARIB and TTC from Japan, and TTA from Korea. It defines the cdma2000 standard which builds on the 2G CDMAone standard. Although data rates are increased roughly in line with the 3GPP standards, the core network is, however, still based on the IS41 core network, making roaming between cdma2000 and 3GPP systems difficult.

4.3 ITU

The ITU [3] continues to have a role to play in the development of mobile standards. For some time, the ITU has had a programme of development work under the 'IMT 2000' banner. When the 3GPP and 3GPP2 bodies emerged as strong developers of 3G standards, the ITU agreed to provide an umbrella framework so that these two standards bodies could be recognised by the ITU as developing the detailed specifications, along with ETSI for the enhanced DECT specification. Work inside the ITU and in groups of ITU members has resulted in significant harmonisation

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efforts which have brought 3GPP and 3GPP2 radio aspects much closer together.

4.4 3G.IP

3G.IP was born in May 1999 out of a desire to bring mobile services firmly into the 'Internet age'. Its primary goal was to put the success of 2G mobile systems, particularly those based on the GSM core network, together with the rapid growth of the Internet and the increasing interest in telephony and other real-time services over the Internet. It started modestly, with the objective to make rapid progress by bringing together like-minded companies (3G systems manufacturers and operators) who could develop the core principles for transporting IP-based multimedia services over a 3GPP system based on EDGE or UTRA.

3G.IP was very successful in establishing an agenda towards 'all-IP' and helping 3GPP to develop the first draft architecture, the first step towards a complete IP multimedia system. Once documents with proposals started to find their way into 3GPP, however, it became clear that 3G.IP could not make the desired progress without becoming much more open and allowing other companies to participate. So 3G.IP started to admit other companies towards the end of 1999, becoming completely open early in the year 2000. 3G.IP has no subscription charges and the only prerequisite for joining is the signing of an agreement which may be downloaded from its Web site [4].

4.5 IETF

The IETF [5] is focused on the development of protocols which run over an IP stack. As mobile standards migrate more and more towards IP-based services it becomes more important that the IP service standards take mobile into consideration. There is currently much interest in the IETF in further development of IETF protocols relating to mobile, including call-control protocols such as SIP, mobility services such as mobile IP, and transport efficiency aspects such as IP header compression. The IETF does not consider system aspects and therefore a close dialogue between the mobile standards community and the IETF is required to produce the right standards which help the system to work effectively.

4.6 WAP Forum

In 1997 several different manufacturers started to develop proprietary methods for converting Internet content into a more compact format for transmission over expensive and bandwidth-limited mobile data channels. It was during a session in a subgroup of ETSI SMG, responsible for the GSM standards at that time, that some of these manufacturers presented their ideas to the standards community. The ETSI standards community was interested, but disappointed that these ideas were not brought into ETSI, as it was obvious that operators could not support multiple different protocols according to the handsets being used at the time by their subscribers. So these manufacturers were given a clear message that they must work together or their ideas would not take off. The WAP Forum [6] was born later that year, with the objective of defining a standard 'micro-browser' to run on mobile handsets, and a suite of protocols which allow that micro-browser to interact with a network server. WAP micro-browsers can be implemented on a variety of 2G handsets, including GSM, CDMAone and US TDMA handsets. During the year 2000, WAP telephones have started to appear on the market and the WAP Forum is moving on to providing a richer environment for delivering Internet content to mobiles.

4.7 Mobile Wireless Internet Forum (MWIF)

While 3G.IP focused on the delivery of an IP multimedia system which builds on 3GPP Release 99, MWIF [7] started early in the year 2000 to study how the existing Internet paradigm could be made mobile. MWIF members come from 3G operators and manufacturers, including mainstream Internet systems suppliers. MWIF also includes the ISP community. MWIF is now producing a proposal for a functional architecture which will be fed into 3GPP and 3GPP2 later this year. The MWIF approach is to define a solution which is independent of access technology and is, in general, much more radical than has been discussed in 3GPP to date, hinting at changing as many as possible of the protocols from today's telecommunications protocols to IP-based protocols.

5. The move to IP architecture and standards impact

Over the past couple of years there has been increasing interest in moving to generalised IP-based architectures and protocols and avoiding expensive specialist protocols and architectures for different implementations of the same service for mobile, fixed, tetherless, etc. In the 3G standards world, one of the most significant impacts is the use of 'voice over IP' technology within the mobile networks. 3G.IP developed an initial architecture which put together the IP call server approach used by both H.323 and SIP with the mobile architecture developed for 3GPP. Instead of carrying voice traffic through expensive MSCs, IP links are established to call servers using the basic IP bearer capability of the mobile network. The call server can then perform largely the same job as in the 'fixed' ISP-based networks, instructing a gateway to set up a call using 'voice over IP' or over the PSTN, and then instructing the mobile to establish another IP bearer channel with higher bandwidth to the gateway for transport of voice traffic.

For 3GPP, however, it is not as simple a process as this. There are a number of aspects which need detailed consideration inside the 3GPP standards process:

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- the security and authentication mechanisms have to be examined to ensure that fraud and eavesdropping are avoided, while maintaining the ability to invoke lawful interception,

- the IP bearer channels for both signalling and voice traffic need to be of high enough quality to ensure that calls proceed without failure and that voice quality is equivalent to the circuit-switched world,

- the service or feature interaction between the call control model and additional services provided by operators, such as prepay, VPN, number translation, etc, needs to be handled to offer the same look and feel as the circuit-switched world,

- when roaming, all interactions must be handled smoothly so that the user does not perceive any difference between roaming on circuit-switched networks and roaming on IP-based networks.

The overall architecture for 3GPP has now been defined, and the additional functions required in the 3GPP core network have been termed the 'IP multimedia sub-system'.

Having addressed these considerations, there are the specific protocols to be considered. 3G.IP made an early decision to press for the use of the IETF session initiation protocol (SIP) as a standardised protocol to be used between the user equipment and the call server. This decision was also adopted by 3GPP. In principle, this means that the IETF standard SIP can just be slotted into place, but, in practice, there will need to be changes made to SIP to accommodate the needs of a mobile network. 3GPP has decided that it will encourage the development of these extensions within the IETF rather than making a 3GPP-specific version of SIP. Since the IETF will concern itself only with the protocol aspects, it is necessary for 3GPP to develop the overall system framework and develop the necessary additional function descriptions before the IETF can work out the details of the required extensions.

Overall, this means that the mobile standards landscape is moving from a position where all mobile standards for a particular system are developed in one standards committee structure to one where different standards structures must co-operate to develop the complete solution. The IP architecture is a particular challenge because the companies involved have to bring together small low-power mobile devices having hard-coded implementations with fast-moving IP standards which expect the latest code to be downloadable on to the end-user device.

6. Conclusions and future outlook on mobile standards

There can be little doubt that the pace of change in mobile is accelerating. Can the standards process keep up and continue to deliver the benefits of standardisation without delaying the introduction of new products and services? The future success of standardisation will be dependent on the ability to position standards in order to protect investments while giving freedom to innovate with new developments.

There is an increased speed of change and an expectation of ever shorter development lead times. However, this needs to be counterbalanced by the very high investment costs in introducing new network technologies, e.g. in the UK alone, the 3G licence cost to BT Wireless of £4bn, plus an expected network investment of a further £2bn, mitigates against a high rate of change. Putting together the world-wide costs of 3G and taking into account all of the different competing operators across all regions will result in a cost running to many hundreds of billions of pounds.

The key is to provide basic standards which provide a sound and stable platform, protecting the fundamental investments, while enabling a change of functionality and capabilities quickly and at low incremental costs. Some of the current developments will help us move to this paradigm:

- creation of linked standards families, giving evolution options and choices for implementation, e.g. the reuse of the GPRS core network in the 3GPP standards suite enables service and investment continuity during the transition to 3G — for this to work well, a long-term vision is required, such that the basic architecture decisions support future evolution,

- the move to IP-based architectures, where services applications can be developed quickly and supported on a simple, universal protocol structure — the creation of application programming interfaces (APIs) at both the network and the terminal is also a key enabler for this,

- the emergence of techniques such as software radio, where terminals and infrastructure can be re-configured by downloading or software upgrade to a new standard.

Another factor relating to the rate of change is the way in which standards are developed. This is now a resource-intensive (but vital) part of the development process. Already, standards are created in cyberspace, with electronic meetings, e-document development and e-voting processes. Even so, the lead time for significant standards developments, such as CAMEL, GPRS or 3G is still of the

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order of 3—5 years. Even relatively small enhancements can take a year to standardise and a further year before deployment. So, one challenge for the industry is to streamline and automate the standards process, with increased use of development tools.

Standards can no longer be developed by small isolated committees. To produce high-quality mobile standards resulting in high-quality global mobile systems with full IP multimedia capability requires development within a number of different global standards organisations. The management and co-ordination of input into all the various forums is a big challenge for all companies in the industry, and, in particular, ensuring that deals struck between companies in one forum are upheld in a different forum will be very testing for all concerned. It is only the major standards players who will be in a position to drive results across all communities and create the right global mobile standards to create and enhance value for their shareholders.

Can standards keep up, and be created fast enough to meet commercial needs? Well, it is the commercial needs which drive the speed of standardisation, rather than vice-versa. The difference perhaps is that standards are driven by the overall industry commercial needs, often being a compromise, and perhaps delaying those who would benefit from a very high standards churn rate.

Overall, the outlook for mobile standards is highly positive — they are an intrinsic and essential component of network and terminal developments, and can clearly be seen to have played a major part in the success and growth of the mobile industry world-wide.

References

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Fred Harrison works in BT Wireless, where he is responsible for directing work on 3rd generation mobile standards. In 1998/99 he took a leading role in establishing the new third generation partnership project standards body (3GPP). He has also been active in the creation of the 3G.IP Focus Group.

He started his career with BT in 1974 as a sponsored student. He studied Electronic Engineering at Southampton University, graduating in 1978. He worked on optical fibre and microwave radio developments until 1990 when he moved to Cellnet, where he was responsible for the overall design and planning of Cellnet's radio network. He then spent two years in BT Group Technology prior to the formation of BT Wireless.

Kevin Holley graduated from Bristol University in 1985 with a BSc in Physics. He joined BT Laboratories that year and he began working on off-air analysis of analogue cellular signalling. His involvement in the global system for mobile communications (GSM) standards work began in 1988 with a study of the reliability of the proposed signalling mechanism. Later in 1988 he began work on the short message service (SMS). In 1989 he was seconded to Cellnet to work on GSM technology development. He returned to BT at Adastral Park in 1992, but has continued his involvement in GSM standardisation and development right up to the present day third generation (3GPP) standards where he is mostly focused on the terminal aspects.

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